DISCUSSION ON "THE LONDON TELEVISION SERVICE"* AND "THE MARCONI-E.M.I. TELEVISION SYSTEM"†.

MERSEY AND NORTH WALES (LIVERPOOL) CENTRE, AT LIVERPOOL, 28TH NOVEMBER, 1938

Prof. E. W. Marchant: I should like to say a word or two about the developments that have taken place which have enabled television transmission to come about. It is not much more than 30 years since the cathode-ray oscillograph was first used in laboratories as a rather specialized scientific instrument, and those of us who remember the difficulties of the experiments that were made in those days will appreciate the immense amount of hard work and scientific investigation that has been needed to produce the apparatus that sends out and receives television to-day. At the University of Liverpool we have made during the last few years a number of experiments with short waves, and we know some of the problems that are involved in their production.

One point of interest is that no less than five microphones are used for a sound broadcast. This means that when one is listening to a broadcast, say, of a concert, one is getting something that one cannot get if one attends the concert. The broadcast version is obtained from a number of microphones in specially arranged positions in the hall, and is therefore a better result than is heard in the hall itself.

I remember seeing the first transmissions that were sent out from Alexandra Palace, in October, 1936. The pictures were extraordinarily good, and no one could wish to have pictures with better definition than we have to-day. The chief criticism that has been made by "viewers" is that the size of the picture is too limited.

I do not think this criticism is justified. Considerable efforts have been made to produce large-scale television pictures, but it seems to me that such pictures would be no advance on what one already gets with the cinema.

The technique that has been developed in connection with television "productions" is one which is only just beginning. As time goes on, we shall realize the possibilities of television far more than we do at present.

I am very interested in Fig. 18 of the paper by Messrs. Macnamara and Birkinshaw, showing the range of transmission round London. Many years ago we found that with short waves transmitted over short distances the kind of thing that produces weakening of the signals is a comparatively small obstacle.

Has any television transmission been received at long range, say in South Africa?

Mr. E. J. Johnston: I should be glad if Messrs. Macnamara and Birkinshaw would confirm that in the case of the Marconi sound transmitter the master oscillator works at half the carrier frequency, and not at twice the carrier frequency as is stated on page 745 (vol. 83). It is noticed that a stability of $\pm$ 1 part in 100 000 is claimed: does this refer to a time period of 24 hours? Is the idea of feeding the master-oscillator filament from a mains-driven rectifier to enable it to be continuously worked, so as to avoid frequency variation?

It would appear that neither the sound nor the vision transmitter is crystal-controlled. In view of the fact that it has been found possible to grind crystals down so as to resonate at frequencies as high as 60 Mc./sec. with a practically zero frequency-temperature coefficient, perhaps the authors will explain why such crystals are not used.

Mr. G. H. Rawcliffe: First, we are told that the maximum modulation frequency is 2·5 Mc./sec. On what basis was this chosen? In sound transmission the desirable modulation frequency has a definite upper limit, this being the frequency of the highest harmonics in the sound wave which are audible to the human ear. In vision transmission it seems to me that there is no such obvious upper limit due to the properties of the human eye, and that the brightness of the picture might vary in space at any rate whatsoever. Now a modulation frequency of 2·5 Mc./sec. and a line frequency of 10 125 lines per sec. give a maximum of about 250 modulations per line, and it is this value which I should like the authors to justify.

Secondly, I understand that the sensitized surface of the Emitron camera consists of a number of discrete particles

* Paper by Messrs. T. C. MACNAMARA and D. C. BIRKINSHAW (see vol. 83, p. 729).

† Paper by Messrs. A. D. BLUMLEIN, C. O. BROWNE, N. E. DAVIS, and E. GREEN (see vol. 83, p. 758).

and I should like to know, roughly, the particle density, and whether this causes any irregularity, or is in any way connected with the modulation frequency.

Lastly, Mr. Blumlein, in Section (4) of the paper, suggests that phase modulation was contemplated instead of amplitude modulation. What factor in vision transmission caused this reversal of sound-transmission practice to be considered, and why was it finally abandoned?

[The authors' replies to this discussion will be found on page 274.]

SOUTH MIDLAND CENTRE, AT BIRMINGHAM, 5TH DECEMBER, 1938

Dr. J. Greig: The points which I wish to raise are concerned primarily with the output stages of the transmitter.

It would be interesting to know whether the adoption of the conventional neutrodyne bridge for the final stage was determined by the fact that suitable water-cooled pentodes were not available commercially at the time the transmitter was designed.

Does the phase displacement for the extreme side frequencies shown by the half-ellipse in Fig. 22 of the paper by Messrs. Blumlein, Browne, Davis, and Green, represent a limiting value of phase-shift which can be tolerated, or is reduction in amplitude still the significant factor?

Two further points of general interest: would it be possible to mention the form of circuit in which the synchronizing pulses are added to the vision signal; and is any special technique, such as the use of a specially built "picture" tube, employed in the transmission of the present standard tuning pattern?

Mr. J. A. Cooper: Having had no personal experience of television or short-wave transmitters, I propose to limit my remarks almost exclusively to the paper by Messrs. Macnamara and Birkinshaw, and to confine them to less specialized matters.

On page 737 (vol. 83) it is stated that, in effect, a television programme is produced before an audience. This being so, one might expect the parallel to a theatre footlights system.

On page 738 it is stated that high-angle lighting is supplemented by spot lamps at floor level. Fig. 7 indicates that these lamps are few in number. It would be interesting to know why the bulk of illumination is of the high-angle type when footlights and general frontal lighting might be expected to give a brighter image in the Emitron.

On the same page it is stated that experiments are to be carried out to determine the suitability of lamps of the water-cooled gaseous-discharge type. As the paper was written in 1937, these experiments have by now probably taken place, and it would be interesting to have an account of the results.

On page 741 it is stated that controls are introduced which take account of the finite time of transmission of the scanning wave-forms and vision signals along the camera cables. Some information regarding the design and operation of these controls would be of interest.

Mr. Blumlein refers in detail to line- and frame-synchronizing signals. Nothing is said in either of the papers to indicate how these signals affect the receiver. They obviously allow time for the flyback operations to take place, but, as the signals are so carefully arranged, I feel there must be some reason why such particular care is taken regarding the various impulses. Could some more information be given on this point?

Mr. S. T. Stevens: In the Emitron camera, by suitably altering the amplitude of the line- and frame-scanning pulses, it is possible to cut down the area of the picture which is being scanned on the mosaic in such a way that if the head and shoulders of a person were normally in the centre of a rather large area of screen the reduction in mosaic scanning would pick out the head and shoulders only of the subject. This would be the equivalent of tracking the Emitron camera forward, although there would be no actual movement. I should be interested to learn whether this practice is in use at Alexandra Palace.

I understand that in the Super-Emitron camera the primary electrons are projected in the optical plane down the tube from what is actually a photocell combination at the front of the tube, and are made to strike a mosaic which is normally photosensitized. It is understood that this mosaic need not be a true mosaic as in the case of the ordinary Emitron camera and that a plain mica plate may be used. Secondary electrons evidently have to be released from this plate to effect the amplification used in the Super-Emitron, and I should like to know how this comes about without there being any secondary-emissive material on the signal plate.

In connection with mechanical receivers, it was found that the original synchronizing pulses given out by the B.B.C. signals were not quite suitable for synchronizing mechanical scanners at the receiving end. I should like to know what changes were afterwards made in the transmitted envelope form of the synchronizing signals, to avoid this difficulty.

Mr. W. R. Bowler: It is understood that the cable used for outside broadcasts must have a very low attenuation factor. The apparatus used for testing the cable sections with a view to balancing these losses must therefore have a high degree of efficiency. Can any information be given as to the type of apparatus used for this purpose, and the degree of accuracy achieved?

Mr. A. E. Stollard: What is the greatest distance over which television has taken place, and what are the possibilities of the range being extended?

Mr. W. Hawking: I should like to know what is the field-strength value necessary for adequate reception of television, and whether this value is directly dependent on the maintenance of an optical path. Is the strength of the field the vital factor determining the limit for satisfactory transmission, or is the high interference/signal ratio that would be experienced at a distance from the transmitting station a more important consideration?

In the southern part of the area shown in Fig. 18 of the paper by Messrs. Macnamara and Birkinshaw we have two contours around Sanderstead and Sutton where high ground exists and where the field strength is approximately 1 to $1 \cdot 25\,\mu V$ per metre. I should have expected

that beyond the high ground on the remote side of the transmitting station the field strength would have fallen away very rapidly, but, on the contrary, it appears to be stronger here than at other points which are at the same radial distance from the transmitter and are less heavily screened.

With regard to the transmission of television by wire and cable, I should be glad of some information as to the difficulty which is being experienced in using the coaxial cable for the transmission of television programmes from London to, say, Birmingham. Is the major difficulty the difference in transmission time between the extreme frequencies necessary for the transmission of the television frequency band?

Mr. H. Joseph: I notice that the figures chosen for the number of lines are all a multiple of 3. For the experimental transmission the number of lines was 30, which is 3×10; in the next attempt the number was 180, which is $3^2 \times 20$; the next 243, which is 3^5; and the final one is 405, which is $3^4 \times 5$. Perhaps Messrs. Macnamara and Birkinshaw would give us the reason for this.

Mr. D. R. Parsons: I notice that in the experimental Baird transmitter used before the Marconi-E.M.I. apparatus was finally decided upon, the original radio frequency was about 1·4 Mc./sec.; and on the mobile transmitter and the Alexandra Palace transmitter now used by the B.B.C. the original operating frequencies used by the master oscillator are 32 Mc./sec. and 22·5 Mc./sec. respectively. This means only one stage of doubling followed by the radio-frequency amplification. It would be interesting to know why such high freqencies were chosen.

The authors do not mention what type of circuit is used in such exceptionally high-frequency master oscillators. For the portable transmitter a stability of 1 part in 5 000 is specified. This is rather a poor stability, but it may be quite satisfactory in view of the large bandwidth of the receivers used and the absence of any other transmitters on neighbouring frequencies.

I notice that the local sound and vision aerials cause a signal of 10 volts to be induced across the input terminals of the receiver used for picking up the signals from the mobile transmitter working on 64 Mc./sec. A filter is used to cut this voltage down by 70 db. Would the addition of a signal-frequency high-frequency stage simplify the design of the filter and also enable some of the more distant outside television broadcasts to be picked up more efficiently?

Mr. T. D. Wright: Messrs. Macnamara and Birkinshaw's pictures of the studio arrangements indicate that the lighting is flooded all over the setting. As the definition in television reproduction depends on the light and shade, would it not be more suitable for transmission and possibly give more definition in the received picture if the light were concentrated, so that the shadows showed up on the forms?

Mr. M. E. Tufnail: Messrs. Macnamara and Birkinshaw refer to the arrangement of lighting employed to produce an illusion of depth. Since the pictures are received on a flat surface, it is difficult to appreciate how the illusion of depth can be given.

The whole subject of television transmission appears to be complicated by the necessity for scanning and synchronization. It has been mentioned that the start of television comprised the invention of scanning, and I should like to ask whether any systems have been contemplated which would not involve scanning. I would point out in this connection that the great majority of early systems of telegraphy involved synchronization of the transmitter and receiver, but these have since been superseded by systems which do not necessitate synchronization.

Mr. C. R. Jephcott: In connection with the frequencies chosen for the sound and vision transmitters, namely 41·5 and 45 Mc./sec. respectively, it would be interesting to learn whether the separation of 3·5 Mc./sec. has been found sufficient in practice to prevent side-band interference completely between the two signals. Is the service area of the station likely to be affected to any appreciable extent for greater power output from the transmitters?

With regard to the mobile ultra-short-wave vision transmitter, will Messrs. Macnamara and Birkinshaw indicate the approximate useful range of this unit.

Lastly, what is the average expected life of a cathode-ray tube as used in a standard television receiver, employing, say, a 12-in. diameter tube giving a 10 in. × 8 in. picture; and what is the screen size adopted in the monitoring equipments used at the London Television Station?

Mr. P. E. Farren: Mr. Blumlein refers to the advantages obtained by interlaced scanning. Apparently only a double interlace is used, and I should like to know whether consideration has been given to triple or quadruple scanning, and whether such scanning would give improved results.

Mr. H. Faulkner: From the design details given in the paper by Messrs. Davis and Green it seems that the plan has been to take a particular valve and work at the maximum power output which can be obtained. This seems to be a reversal of the normal process of design, in which one would have expected a particular power output to have been decided upon and the valve transmitter to have been designed in such a way as to give this power output. It seems to become a question of the design of a suitable filament when given the required emission, which is not a very difficult problem. There may, however, be limitations in the practical design of this type of valve for use at these frequencies, and it would be interesting if the authors would indicate what are the present limits of development in this direction.

As regards the arrangements to ensure that the frequency of the frame is held in synchronism with that of the grid supply, I should be interested to know whether the hour-to-hour variations which must occur in the frequency of the grid supply are sufficient to cause any trouble. The number of cycles generated by grid stations is a fixed quantity over a particular period of time. This is made possible, it is understood, by a slight speeding-up or reduction in frequency from time to time.

The use of demountable-type screen-grid valves on the Baird system of television described in Messrs. Macnamara and Birkinshaw's paper is of interest. Valves of this type have also been used in the short-wave trans-

mitters of the Post Office, and were in fact developed by the Metropolitan-Vickers Electrical Co. for that purpose at the request of the Post Office. The feature of this kind of valve which allows more flexibility in electrode design, especially during experimental stages, is a very useful one, and screen-grids have obvious applications in short-wave work.

Mr. J. J. E. Aspin: I should like to know whether the authors have conducted experiments on the spacing of directors and reflectors in the case of television receiving aerials and the transmitting arrays used at Alexandra Palace, and, if so, whether the findings were in agreement with those of G. H. Brown,* who suggests spacings less than a quarter of a wavelength in the case of simple dipole aerials.

Mr. H. G. S. Peck: One cannot but be struck by the enormous amount of work which has been done in developing television in a comparatively short time. While television is an extension of sound radio-communication and telephony, it is a very great advance in every way upon what has already been done in these two branches of electrical engineering.

The Post Office has provided a system of special cables for outside television broadcasts connecting strategic points in London with Broadcasting House and Alexandra Palace; it is interesting to learn that it is possible to extend this by the use of a link consisting of ordinary telephone cable up to 2 miles in length if it is suitably equalized.

The authors say very little about the coaxial cable which has been laid between London, Birmingham, and Manchester. If television becomes at all popular, I can imagine that the Post Office engineers will be very busy in doing what they can to eliminate interference.

THE AUTHORS' REPLIES TO THE DISCUSSIONS AT LIVERPOOL AND BIRMINGHAM

Messrs. T. C. Macnamara and D. C. Birkinshaw (*in reply*): Prof. Marchant inquires whether any television transmission has been received at long ranges. It so happens that only a week or two ago we received reports of reception of both sound and vision at considerable distances. In March, May, and October of 1938 the sound was consistently received in Rhodesia, and we have also reports of reception in Baghdad and Cairo. More interesting still is the fact that on the 3rd November, 1938, the Radio Corporation of America at Riverhead, New York, reported reception of the vision signal in the form of recognizable images, accompanied, however, by shadows due to multi-path reception. Two days later they received an intelligible picture for 2 hours. The Postmaster-General's Department in Victoria, Australia, has also received the sound. In addition, the vision signal has been received in South Africa at such an intensity that it is considered that had a television receiver been available it would have been possible to interpret the signal as a picture.

We are indebted to Mr. Johnston for pointing out an error in the paper. He is correct in assuming that the master oscillator of the sound transmitter works at half the carrier frequency, and not at twice the carrier frequency. The degree of stability claimed, i.e. $\pm$ 1 part in 100 000, does obtain over a period of 24 hours, but is intended to be interpreted as obtaining over the period of a transmission. At the time the paper was compiled neither of the transmitters was crystal-controlled, but apparatus to originate the master frequency at 1/12th of the carrier frequency by crystal control has now been installed.

In reply to Dr. Grieg, we do not use a specially-built picture tube to transmit the present standard tuning caption. What happens is that the caption is drawn on a card, and a short length of film prepared from this, the film being used in a stationary position in the telecíné apparatus.

Messrs. Cooper, Wright, and Tufnail raise some interesting questions as regards television studio lighting. It has been found that any system of lighting arranged on the same lines as those employed in a theatre is unsatisfactory, in that the resulting picture has a very flat appearance. This is because television has, as it were, only one eye, and cannot of itself see the picture in three dimensions. It has long been known, in connection with the production of films, that if a system of lighting is adopted wherein the light is concentrated on the subject from the back, top, and sides, with only a minimum of diffused frontal lighting, then a useful impression of depth is secured in the picture. It is for this reason, apart from inconvenience, that footlights of the theatrical type are not used on the floor, and the bulk of the illumination is of the high-angle type. Experiments of gas discharge lamps have so far been unsatisfactory, since it is a feature of all such lamps that the light emitted depends on the instantaneous strength of the current, and when they are used with an a.c. supply this effect causes interference bands in the picture. The use of a d.c. supply for such lamps is somewhat impracticable owing to the large wastage of power which must occur in the stabilizing arrangements, and because of the bulky ancillary apparatus required.

Mr. Stevens mentions the question of synchronizing pulses *vis-à-vis* mechanical reception. It has not been necessary in this connection to make any change in the transmitted envelope form of the synchronizing signals; all that has been done is to ensure that any phase changes of the signals shall take place, if at all, very slowly instead of rapidly as was originally the case. In these circumstances, it is possible for a receiver possessing comparatively high inertia to keep itself in step.

Mr. Stollard inquires about the possibility of the extension of the range of television. No increases of power in the London Television Station have so far been contemplated, and any question of extending the service by means of additional stations is subject to future decisions to be made by the Television Advisory Committee.

The question of the necessary value of field strength for adequate reception of television, put by Mr. Hawking, is a little difficult to answer in a general way, as it depends entirely upon the strength of local interference, which may vary considerably. Experience seems to show, however, that in the absence of serious local interference,

* *Proceedings of the Institute of Radio Engineers*, 1937, vol. 25, p. 78.

as, for example, where the receiving aerial is not situated very close to a road carrying heavy traffic, a figure of $\frac{1}{4}$–$\frac{1}{2}$ mV/m. may in general be quoted as being satisfactory, especially if an efficient directional aerial system is employed. With regard to the transmission of television signals from London to Birmingham via the coaxial cable, we are not aware that any particular technical difficulty exists.

Mr. Jephcott refers to the question of the adequacy of the 3·5-Mc./sec. frequency separation between the sound and vision transmitters. Such a separation has been found in practice to be entirely adequate in view of the fact that the upper vision modulation frequency is of the order of 2·5 Mc./sec. It is thought probable that were greater power to be developed from the vision and sound transmitters, the service area of the station would be augmented in due proportion. The maximum useful range of the mobile ultra-short-wave vision transmitter is at the moment of the order of 20 miles, but it is considered possible that this may be extended by development work upon the aerial systems employed. As regards the average life expected of a cathode-ray tube, it is difficult to generalize, for much depends upon the conditions under which the tube is operated, but it may in general be said that the expected life is about the same as that of the average small receiving valve. The picture monitors used at the London Television Station develop a picture size of 10 in. × 8 in.

Messrs. A. D. Blumlein, C. O. Browne, N. E. Davis, and E. Green (*in reply*): In reply to Mr. Rawcliffe, allowing for the lost time between lines, his figure of 250 modulations is reduced to about 210. On the other hand, 210 complete cycles are capable of reproducing 210 black and 210 white dots giving a total of 420 dots altogether. Now, in the vertical direction at the most only 385 black and white dots can be reproduced, and this only when the dots coincide with the scanning lines. Allowing for the fact that the scanning lines may not coincide with the vertical detail, the statistical average number of black and white dots that can be resolved vertically is considerably less than 385. Hence, with 2·5 Mc./sec. an adequate horizontal detail is obtained in comparison with the vertical detail. As regards the surface of the Emitron screen, the particle size is so small that there are a large number of particles to each picture dot, so that no discernible irregularity is produced. A modulation method suitable for sound is not necessarily suitable for television, so that all practicable forms were examined, with the result stated.

In reply to Dr. Greig, pentodes of suitable rating were not available at the time the transmitter was designed. The phase displacement mentioned refers of course to the radio frequency of 45 Mc./sec. and is therefore minute when referred to the highest modulation frequency. It therefore follows that considerably more phase displacement may be tolerated, provided the condition is consistent with efficient operation of the power amplifier.

The synchronizing and vision signals are mixed by two valves having their anodes in parallel with a common anode load. Negative picture signals and positive synchronizing signals are applied to the two grids, and the mixture in the anode circuit is applied to the distribution amplifier.

In reply to Mr. Cooper, the correction for camera-cable delay is made by retarding for about 5 microseconds the triggering impulses for all pulse generating units except for the camera scanning and black-out pulses, thus relatively advancing these latter pulses. These pulses are passed through controllable delay networks to the cameras, which delay networks, together with the length of camera cable, absorb this relative advance, so correcting for the cable delay.

In deciding on the waveform to be transmitted, the shape of the synchronizing pulses were as far as possible fixed by functional considerations and not with reference to a particular receiver circuit. In general, the synchronizing signals are separated from the vision signals by a suitably biased non-linear device; and the leading edges of the signals are separated from the long frame signals by frequency selection.

In reply to Mr. Stevens, an effective "close-up" can certainly be obtained by reducing the scan, but a very great reduction of scan results in poor sensitivity and reduced resolution; further, on normal Emitrons, prolonged reduced scanning slightly marks the tube and leaves a rectangular shadow when normal scanning is resumed. The beam has not this effect on a super Emitron, which therefore allows of "electrical zooming."

The Super-Emitron has been described in a recent paper by Messrs. McGee and Lubszynski,* but it may be pointed out that it is unnecessary to have a mosaic of metal elements, as the charge can be induced on the mica surface owing to the secondary emission of the mica itself, which secondary emission is improved by the presence of caesium in the tube.

In reply to Mr. Bowler, the cable constants were originally obtained by open-circuit and short-circuit bridge measurements on short lengths, the overall losses being measured by comparison with a carefully constructed resistance attenuator.

In reply to Mr. Joseph, factors of 3 have certainly been prevalent in the number of scanning lines. For mechanical scanners, numbers like 30, 180, and 240, were convenient because the scanning discs were laid out on dividing heads marked in degrees. The number 243 which was at first used for electrical interlaced scanning was chosen as a convenient number close to 240 (then used for mechanical sequential scanning), which at the same time was an odd number made up of small factors, the small factors being convenient for electrical frequency division. The number 405 was again a convenient number close to 400 and was obtained by changing one of the factors of 243 from 3 to 5. The necessity for low factors no longer exists, as improved counters have been developed which will count comparatively large primes.

In reply to Mr. Parsons, the problem at the relay receiver was not that of preventing heterodyne interference from the main transmitter, but of preventing intermodulation effects on the first valve of the radio receiver. With the valves then available a high-frequency valve would, owing to its small feed, have been no quieter, and no less prone to intermodulation troubles than the mixer triode employed.

In reply to Mr. Tufnail, a large number of systems have been proposed which transmit a characteristic continuous

* *Journal I.E.E.*, 1939, vol. 84, p. 468.

signal for each picture point and do not therefore require synchronizing. It should, however, be pointed out that the more modern telegraph signalling systems are essentially "start-stop" synchronized rather than regularly synchronized. Television receivers may be made which are entirely "start-stop" synchronized, but in practice a compromise between "start-stop" and regularly-running synchronization is employed.

In reply to Mr. Farren, a triple interlace, having for any two successive frames not an equal upward and downward displacement of the lines, gives, according to the convention chosen, an apparent continuous upward or downward progression of the scanning lines. This apparent progression is exceedingly confusing to watch unless the picture frequency is raised to a high value, which of course makes the picture satisfactory without interlacing. With a quadruple interlace this effect is worse, unless an irregular sequence of line displacement is used, in which case, apart from the complexity of equipment, in order to obtain a satisfactory result a high picture frequency is again required so that no advantage is obtained.

In reply to Mr. Faulkner it may be stated that engineering design is primarily governed by commercial requirements. The production of high-power radio valves is no exception, and the pioneer designer exploring new applications has, initially, to accept existing technique. Power amplification with triodes at frequencies such as 45 Mc./sec., with modulation bandwidths of the order of 2·5 Mc./sec. depends upon the maintenance of a correct balance of various factors in valve design. The chief of these are: peak filament emission, anode-to-grid capacitance, current-carrying capacity of grid structure, dead-loss capacitance of anode, high d.c./a.c. conversion factor, low electron transit time.

At the present time it would appear there is no technical limit in valve design to meet immediate probable commercial power demands. The slow variations of grid-supply frequency do not give any trouble, but trouble has been experienced on mechanical receivers when the scanning frequency is made to follow very rapid phase-shifts in the power supply.

In reply to Mr. Aspin, pairs of dipoles can be made to develop their directional diagrams at very close spacings indeed, but any reduction below about a quarter-wave spacing produces a reduction in the band width of the aerial and was not therefore contemplated for television.

NORTH MIDLAND CENTRE, AT LEEDS, 17TH JANUARY, 1939*

Mr. R. J. Hines: The first question I should like to ask is in relation to the statement, made in Part I of the paper, that no practicable means was discovered of single-sideband transmission owing to the width of the band required and the necessity for transmitting down to zero frequency. I should have thought that the greater the band width to be transmitted the greater the advantage to be obtained. I can realize that the necessity for transmitting down to zero modulating frequency will make it impossible to suppress the whole of one sideband without getting rid of some of the other, but I do not quite understand why no advantage is gained by partial suppression of one sideband. Accepting, however, the necessity for full double-sideband transmission, one comes next to the question of the actual width of the bands transmitted. One gathers from the paper that the modulation frequency required for 405-line scanning is about 2·5 Mc./sec. This may be the maximum frequency which one must have to gain the full advantage of 405-line scanning, but there are present frequencies considerably in excess of that frequency. It is stated on page 774 that the modulation amplifiers are so designed that at 3·5 Mc./sec. the frequency characteristic is approximately 2 db. down. Now 3·5-Mc./sec. modulation of a carrier of 45 Mc./sec. brings us to 41·5 Mc./sec., which is the carrier for the speech, and I am not clear how interference between the vision and sound transmission is avoided.

The second question I want to put is in relation to film transmission. The television scanning is done at 25 frames per sec., and the film projector for transmitting sound film must run at 24 frames per sec. in order to give perfect reproduction of sound. How are these two requirements reconciled?

(*Communicated*) Since the presentation of the paper in Leeds I have been indebted to one of the authors for the opportunity of withessing television, and recollection of the occasion prompts me to inquire why the film transmissions appear to be less satisfactory than those direct from the studio. Apart from the fact that the film may include pictures too full of detail or otherwise unsuitable for reproduction on a small scale, the film transmissions appeared to me to be subject to distortion which was noticeably absent from the studio transmissions. Is this because of the impracticability of applying corrections, e.g. for "tilt" and "bend," to pictures the subject matter of which is changing every few seconds?

Apart from the distortions, some of the pictures seemed to lack luminosity and contrast, the last fault I should expect to find in a film transmission, the illumination available for which should be productive, one would think, of a particularly strong signal.

Mr. W. F. Smith: It is stated on page 760 that the synchronizing signals are represented by a very low (and, very preferably, practically zero) carrier, whilst on page 766 a figure of 5 % of the peak carrier is quoted. This presumably implies approximately 100 % modulation of the carrier by the synchronizing pulses. The result of this at the receiver will be a very weak radio signal, necessitating the employment of a very sensitive receiver to detect the synchronizing signal. The receiver must also be capable of handling a very high signal strength corresponding to the "white" transmission. To attain fidelity of reproduction over such extremes in volume seems to present considerable difficulty in receiver design.

Regarding the nature of the illumination employed in the film projector, it is stated by the authors that the mosaic is exposed to the film only during the interval between successive frames of the television scanning (a period of only 0·001 sec.) and that two exposures of the

* Only the paper by Messrs. A. D. BLUMLEIN, C. O. BROWNE, N. E. DAVIS, and E. GREEN ("The Marconi-E.M.I. Television System"), was read at this meeting.

film are made in this period. This implies an extremely narrow slit in the shutter and consequently little effective lighting on the mosaic. Is any special illumination employed?

In regard to the cooling of the transmitter valves, it is noted that water is employed as the cooling agent. Presumably distilled water is employed in a closed circulating system, this in turn being cooled either by air or by immersion of a portion of the circulating system in ordinary water from the public supply. Since small capacitances assume considerable importance at very high frequencies, it would seem important to keep the capacitance to the very lowest possible limit. I should like to know whether any experiment has been carried out utilizing oil as the cooling agent. This appears to provide a means of keeping the capacitance down, since oil has a lower specific inductive capacity than water.

External interference to television receivers is likely to be experienced chiefly from such sources as motor-car ignition systems and electromedical apparatus. Both these sources give rise to high frequencies near the television band and, in effect, act exactly like short-wave transmitters.

As regards motor-car ignition interference, some tests made by the Post Office as long ago as 1931 showed that a peak of interference occurred at about 17 Mc./sec., the interference falling off fairly rapidly on either side of this frequency. The tests were not extended beyond about 20 Mc./sec., where the interference was approximately 2·5 db. below that at 17 Mc./sec. This peak interference was approximately 1 μV per metre at 15 yd. from the source. It is unlikely, therefore, that interference from motor-car ignition will be experienced over a wide area. It will be confined mostly to receivers near the main roads. What is the authors' experience of this interference with television programmes?

The presence of such interference, even though it be small, may have an important effect, in view of the low level of synchronizing signal previously referred to.

Other interfering apparatus, such as electric motors, is unlikely to produce interference with the actual received signals, but the mains-borne component of interference may affect the picture by upsetting the electrostatic and electromagnetic fields upon which the action of the cathode-ray tube depends. Complete screening of the cathode-ray tube seems, therefore, to be necessary.

In view of the interest in the question of relaying television programmes to the provinces, I should be glad to know whether a split-band method of transmission over cable pairs is feasible. The feature I have in mind is the splitting of the television band into a suitable number of components, each being converted to a band of frequencies which is capable of transmission over the cable. This will result in a number of frequency bands (say, each up to 120 000 cycles per sec.) each conveyed over one pair of a carrier-telephony type of cable. Twenty such pairs would seem to be sufficient to carry the television intelligence of one transmission.

Mr. R. T. A. Dennison: My first point is in connection with the synchronizing impulses. There are two types of pulses provided—one for indicating the termination of each line and the other for indicating the termination of each frame. In the television receiver two pulses are provided for control of the line and frame scanning, and I understand that the pulses provided by the transmission are simply to ensure that the receiver pulses are triggered off at the right moment at the end of the line or frame. If the pulses in the receiver can be relied upon, it seems to me that one of the transmitted pulses, say the line pulse, can be done away with and economies effected in the cost of the television receiver and, possibly, in the transmitting equipment. In this connection I would point out that mechanical receivers have a machine which drives the scanning device. Being mains-driven, it should provide the correct line frequency, and the transmitter pulse could then be used solely to check groups of lines, i.e. each frame.

My second point is in connection with mechanical receivers, which I understand are coming on to the market now. When the television transmitter was first installed at Alexandra Palace the cathode-ray type of receiver was the only kind which gave good high-definition results, and when the mechanical type of high-definition receiver was introduced some modifications were necessary, I believe, at the transmitter. I should be interested to know whether the transmitter is now able to provide all the pulses and signals which may be required for the control of television receivers. If so, then the design of television receivers will be simplified and more scope afforded to the manufacturers.

A final point is in connection with the size of the receiver screen. I have seen demonstrations of both large- and small-screen receivers and have been impressed with them; but in watching studio broadcasts it is very noticeable on large television screens that when the head and shoulders of the subject is televised, or when the studio is occupied by one or two artists only, a large amount of space exists which could advantageously be filled in with more people or some scenery. Is this due to some restriction in the size of the studio available, or has it something to do with the angle of vision of the lens used in the television camera?

Messrs. A. D. Blumlein, C. O. Browne, N. E. Davis, and E. Green (*in reply*): In reply to Mr. Hines's observations on single-sideband working, no satisfactory method of single-sideband transmission had been developed at the time the Marconi-E.M.I. transmitting equipment for Alexandra Palace was contemplated. We felt justified, therefore, in refraining from the inclusion of a method of transmission which might complicate the issue in a station which was to give pioneer service. With full double-sideband transmission the selection of a sound carrier separated by only 3·5 Mc./sec. from the vision carrier was criticized, but in practice the amount of energy transmitted in the vision signals 3·5 Mc./sec. from the carrier frequency has been found to produce negligible interference in the sound channel.

In regard to film transmission, with intermittent projectors as described, the film is run at 25 frames per sec. although the film is recorded at 24 frames per sec.; the difference introduced being almost negligible in respect of both vision and sound. Since the paper was written, however, film transmitters of the continuous-motion type have been installed which may, of course, be run at any required speed irrespective of the frame frequency.

The rapidly changing character of film pictures does

introduce some difficulty into the "tilt" and "bend" adjustments, inadequately illuminated scenes giving rise to unsatisfactory television images. But a greater difficulty arises in that films are printed with a gamma value considerably greater than unity. Effectively, an increase of gamma is usually introduced by the receiver characteristic, which provides a satisfactory picture from actual scenes but is over-contrasted when the picture originates from film which has been printed with a high contrast.

In connection with Mr. Smith's remarks, it will be understood, of course, that the commencement of a synchronizing signal is represented by a change of carrier from 30 % of peak to substantially zero; the receiver therefore does not need to be very sensitive to detect the synchronizing signal.

The source of illumination used in each intermittent film transmitter consists of a 30-volt 30-amp. projection-type lamp. In the interests of light efficiency, the optical system is so arranged that the shutter interrupts the light at a position where the beam has a very small cross-section.

Oil has largely been used as a cooling fluid in commercial short-wave transmitters. Its advantages of low specific inductive capacity and high resistivity are, however, offset by its low thermal conductivity, the attendant fire risk, and its cost. In the transmitter under discussion,* unwanted additional anode capacitance and losses are avoided by the insulated inlet and outlet of the water cooling-system being positioned in the assembly at a point of zero or almost zero high-frequency potential.

We have made no extensive tests on the distribution of interference over the ultra-short-wave frequency spectrum. Under average conditions about 500 μV (peak) is required to operate a television receiver satisfactorily, so that very local motor-car interference only is likely to prove objectionable. It is frequently necessary, however, to erect a simple directional aerial to improve the receiving conditions in circumstances of poor field strength in comparison with local interference.

No consideration has been paid to any split-band method of transmission of television signals over cables, such as Mr. Smith suggests, but it is improbable that the method would offer any advantages over systems of cable transmission which have already been worked out, especially in view of the complexities which would be introduced when the attempt was made to re-assemble the signals from the various channels.

Mr. Dennison's observations on the necessity of synchronizing signals in the case of a uniformly-running scanning system, are adequately met by Section (5) of Part I of the paper. The mechanical generator for the master frequency signals described in Section (6) of Part II produces satisfactory signals for mechanical receivers, but since the paper was written this machine has been replaced by an electrical generator giving signals which also meet the requirements of mechanical reception.

The size of the studio is of course very limited for some productions, and this may account to some extent for an absence of background in the pictures. In view of the limited depth of focus of the standard cameras, however, it is considered that the producers do well to omit irrelevant detail.

WESTERN CENTRE, AT NEWPORT, 13TH MARCH, 1939†

Mr. J. V. Lugg: I understand that when it was decided to provide coaxial cables, between London and certain other large centres in England, two of the conductors were intended for the distribution of television signals. Can the author give details of any tests which may have been carried out in this connection, and also state the results of these tests?

Mr. W. Roberts: I notice that the picture is scanned completely in $\frac{1}{25}$ sec. Has this time been constant from the first, or has it been arrived at by a process of trial and error? In other words, what is the maximum retentive time of the human eye?

Could not the blind spot which occurs during scanning, when the camera has to go back from right to left without doing any useful work, have been avoided by a continuous process of scanning from left to right and then right to left? It seems to me that this would save time and avoid the mechanism having to travel backwards.

Mr. G. G. E. Lewis: The operation of the Emitron camera is dependent upon the photo-emissive nature of the mosaic and the property of the scanning beam whereby it is able to restore electrical equilibrium to the individual globules of silver which constitute the mosaic. It would be of interest to know what happens to the free electrons released by the lighter portions of the image.

I gather that in the system of outside broadcasts used by the B.B.C. the transmission from the mobile unit is effected by a radio link; are there any differences, such as depth of modulation, frequency of synchronizing pulses, and other characteristics, between the radio-link signal and the signal radiated from Alexandra Palace? My object in putting this question is to learn whether viewers of television might receive the actual signal from the mobile unit if suitably placed in its beam.

Mr. D. E. Blake: It appears that other countries have adopted different standards from that prevailing in this country so far as the number of lines is concerned. I should be glad to know whether these different figures have any mathematical significance, apart from the fact that an odd number of lines is adopted to simplify the attainment of interlaced scanning.

To the viewer, only one thing matters and that is the picture he is looking at—its size and its definition. I feel that, when the novelty has worn off, viewing for any length of time may become somewhat trying with the present sizes of picture, and particularly when a number of people are interested at the same time. Is there any scope for the development, for home use, of the methods employed in cinemas where the pictures are projected on to a screen?

Regarding the televising of plays, I have read that sometimes it is an advantage to film the play first, as this allows of editing, as in ordinary films, with a consequently better artistic result. True though this may be, I feel that it would defeat largely one of the main attrac-

* See vol. 83, p. 785.

† Joint meeting with the Institution of Post Office Electrical Engineers. Only the paper by Messrs. T. C. MACNAMARA and D. C. BIRKINSHAW ("The London Television Service") was read at this meeting.

tions of television, namely that the viewer is viewing the artists at the same time as they are performing. This gives a sense of intimacy, such as one experiences in a theatre, which adds greatly to the entertainment value and compensates considerably for any deficiency in the picture. There will, of course, be many instances where films will give first-class entertainment, but I think that, generally, the televising of films, however good, should form a comparatively small part of television programmes.

Mr. E. S. Loosemore: Are the standards of definition, namely that a television picture should not be inferior to a standard of 240 lines per picture and 25 pictures per second, nominal or effective? If they are nominal the time occupied by line and frame flybacks and by black edging would reduce appreciably the number of lines per picture.

The construction of the Emitron and of the Super-Emitron is such that, in operation, the angle of incidence of the electron beam on the photo-electric mosaic varies considerably. What arrangements are made to maintain the beam focused on the mosaic?

Mr. C. A. Beer: The author states that a ratio of carrier frequency to modulating frequency of the order of 20 to 1 is desired. I should be glad to know whether a lower carrier frequency is impracticable, bearing in mind the problems of amplifier design and possible interference between side-bands. In carrier telephone circuits, the lower ratio is often used.

Is it to be inferred, in accordance with Fig. 19 and other references in the text, that the limiting commercial range of operation is 150 km., or can the transmitted power be considerably increased?

In a complete set of studio equipment with its apparent complexity, there is a very large number of valves and the failure of one during critical operations may be relatively serious. Is this problem catered for substantially by the provision of two or more units in the studio while valve replacements and adjustments are being made? It is the practice in this country on more recent Post Office high-frequency carrier systems where this feature arises, to arrange an automatic change-over from a main to a reserve amplifier.

Messrs. T. C. Macnamara and **D. C. Birkinshaw** (*in reply*): Mr. Lugg refers to the coaxial cable between London and provincial centres. A considerable amount of work has been done by the General Post Office on this cable; the question of the publication of the results is, of course, a matter for that authority.

Mr. Lewis asks about the modulation and other characteristics of the radio signal as transmitted by the mobile outside-broadcast transmitter. The signals are entirely the same as those radiated from the Alexandra Palace, except that for certain technical reasons the picture-signal/sychronizing-signal ratio is somewhat less. It would certainly be possible for viewers to receive the actual mobile-transmitter signal if suitably placed in its beam, but such a course would not present much advantage, as it automatically follows that they would be in a region of high field-strength from the Alexandra Palace and the main transmission would provide a more suitable signal. The latter signal also contains captions and other continuity material inserted at Alexandra Palace.

Mr. Blake mentions the possibility of filming a play and then televising the subsequent film. This procedure is not felt to be entirely desirable as, in addition to the extra cost involved, the psychological effect of knowing that the transmission is instantaneous is considered to be important. In any case, it is doubtful whether the improvement in the performance due to editing would be sufficient to justify the cost of initially preparing a film of the play.

The important aspect of valve failure is raised by Mr. Beer. As he states, there is a very large number of valves in the studio equipment, but in general the problem is catered for, as he suggests, by the provision of spare units in the studio, so that it is unlikely that valve failure will interfere more than momentarily with the transmission. Any change-over to spare apparatus is made manually, as, owing to the fact that operators must be continually at hand during a transmission, automatic features are scarcely necessary.